APPENDIX A:

CCPI AND ICCS PROJECT FACT SHEETS

CLEAN COAL POWER INITIATIVE

INDUSTRIAL CARBON CAPTURE AND SEQUESTRATION

APPENDIX A: CCPI AND ICCS PROJECT FACT SHEETS

CLEAN COAL POWER INITIATIVE

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PROJECT FACTS

Clean Coal Power Initiative (CCPI 3)

Summit Texas Clean Energy, LLC: Texas Clean Energy Project: Pre-Combustion CO_2 Capture and Sequestration

Background

A need exists to further develop and bring to commercial practice carbon management technologies that capture and store or beneficially reuse the carbon dioxide (CO_2) that would otherwise be emitted into the atmosphere from coal-based electric power generating facilities. Carbon capture, utilization and storage (CCUS) technologies offer great potential for reducing CO_2 emissions and mitigating mankind's contribution to global climate change without seriously impacting energy use or hindering economic growth.

Under the second closing of the Clean Coal Power Initiative (CCPI) Round 3 program, the U.S. Department of Energy (DOE) is providing financial assistance, including funding under the American Recovery and Reinvestment Act (ARRA) of 2009, to industry for the purpose of demonstrating the commercial viability of next generation technologies that will capture CO_2 emissions from coal-based electric power generating facilities and either store those emissions, or beneficially reuse them. Once demonstrated, the technologies can be readily considered in the commercial marketplace by the electric power industry.

Project Description

The Texas Clean Energy Project (TCEP) was awarded on January 29, 2010. The TCEP will be a greenfield integrated gasification combined cycle (IGCC) poly-generation facility with fully integrated CO_2 capture to be located in Penwell, Ector County, Texas. The TCEP will produce electricity for export to the grid and other high-value marketable products, including CO_2, urea, and sulfuric acid. The IGCC facility will deploy Siemens commercial gasification and power block technologies. Two SFG-500 (500 megawatt-thermal) gasifiers will produce syngas that will be quenched, cleaned and shifted to a high-hydrogen (H_2) concentration. The power block will consist of one SGT6-5000F combustion turbine, one triple-

Early Rendering of TCEP IGCC Facility

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PROJECT DURATION

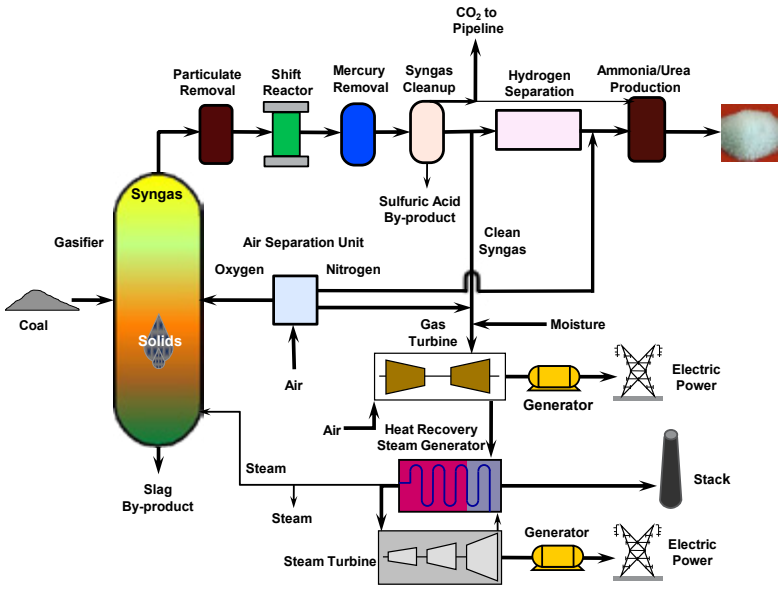
Start Date
02/01/2010

End Date
07/15/2017

COST

Total Project Value
$1,726,628,229

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.



CO_2 Capture and Storage Concept

pressure heat recovery steam generator (HRSG) and one SST-900RH reheat steam turbine for power generation rated at 400 megawatts (gross). The facility will use water-gas shift and Linde Rectisol® acid gas removal technology to capture about 90 percent of the total CO_2 produced from the facility.

The captured CO_2 will be divided into two streams. About 21 percent of the CO_2 will be used in producing approximately 2,156 tons per day of urea fertilizer. The balance of the CO_2 will be compressed for transport by existing regional pipelines to oilfields in the west Texas Permian Basin for beneficial use in enhanced oil recovery (EOR) operations with concomitant geologic storage. The west Texas Permian Basin is the largest market in the world for CO_2-flood EOR.

Goals/Objectives

The project goal is to advance CCUS technologies from the demonstration stage to commercial viability. The project objective is to demonstrate CO_2 removal from the entire pre-combustion synthesis gas (syngas) stream of a green-field IGCC poly-generation facility, the compression and transport of the pipeline quality CO_2, and the monitoring, verification and accounting (MVA) of the disposition of the CO_2 used in EOR applications with concomitant storage.

Benefits

The Texas Clean Energy Project represents an important step in advancing the commercialization of technologies that capture CO_2 from pre-combustion syngas in existing and new electric generating power plants. Standards that limit CO_2 emissions from coal-based electric generation stations do not yet exist, but it is possible that this type of regulation may be enacted in the near future. By producing electricity and other marketable products, while simultaneously capturing and storing greenhouse gas emissions, the project will demonstrate that domestic coal can remain a viable energy source to meet the Nation's growing energy demands while minimizing the potential environmental impact. Additionally, the project will demonstrate that the poly-generation approach is an economical route for IGCC technology. Specific project benefits are as follows:

- The capture of up to 3,000,000 tons per year of CO_2 from the entire plant syngas stream prior to combustion.
- Long-term geologic storage of the captured CO_2.
- Increased domestic oil production, which will contribute to national energy security.
- A path forward for existing and new coal-based power plants to continue to provide economical energy production while meeting environmental sustainability goals.

FE0002650, March 2012

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PROJECT FACTS

Clean Coal Power Initiative (CCPI 2)

Demonstration of a Coal-Based Transport Gasifier

Background

Coal is an abundant and indigenous energy resource and currently supplies almost 38 percent of the United States' electric power. Demand for electricity, vital to the nation's economy and global competitiveness, is projected to increase by almost 28 percent by 2040. The continued use of coal is essential for providing an energy supply that supports sustainable economic growth. Unfortunately, nearly half of the nation's electric power generating infrastructure is more than 30 years old and in need of substantial refurbishment or replacement. Additional capacity must also be put in service to keep pace with the nation's ever-growing demand for electricity. It is in the public interest to upgrade the nation's energy infrastructure with the latest and most advanced viable technologies to achieve greater efficiencies, environmental performance, and cost-competitiveness.

The U.S. Department of Energy (DOE) Office of Fossil Energy, through the National Energy Technology Laboratory, is charged with the implementation of the DOE's Clean Coal Power Initiative (CCPI). The intent behind the CCPI is to leverage public and private investment to secure low-cost energy production and protect the environment. The goal of this program is to demonstrate a new generation of innovative coal-utilization technologies in a series of projects carried out across the country. These demonstrations are conducted on a commercial scale to prove the technical feasibility of the technologies and to provide technical and financial information for future applications. The U.S. Department of Energy awarded Southern Company Services a cooperative agreement under the CCPI Round 2 Program to provide direct financial support for the development and deployment of the Transport Integrated Gasification (TRIG™) technology that is being utilized by the project.

Project Description

The Kemper County Project (Kemper County Energy Facility) is a lignite-fueled integrated gasification combined-cycle (IGCC) facility being constructed in Kemper County, Mississippi. The plant design incorporates the air-blown TRIG™ technology jointly developed by Southern Company, KBR, and DOE at the Power Systems Development Facility in Wilsonville, Alabama. Mississippi Power Company (MPC), a Southern Company subsidiary, will own and operate the plant. The facility will employ state-of-the-art emission controls to produce electricity from lignite in an efficient and environmentally friendly manner and will also assist MPC in achieving key strategic objectives of fuel and geographical diversity, and cost stability, while providing a reliable economic resource to meet customer needs.

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Mississippi Power Company
KBR, LLC

PROJECT DURATION

Start Date	End Date
01/30/2006	05/01/2018

COST

Total Project Value
~ $3,000,000,000*

DOE/Non-DOE Share
$270,000,000 / $2,800,000,000

*Note: The cost above includes scope in which DOE is not participating in cost sharing under the CCPI.

U.S. DEPARTMENT OF ENERGY

Lignite reserves near the plant site owned by Mississippi Power Company and developed and mined by Liberty Fuels, a subsidiary of North American Coal Corporation, will supply the feedstock for the IGCC plant. The estimated nameplate capacity of the plant will be 830 MW with a peak net output capability of 582 MW. The peak capacity of 582 MW occurs when using syngas in the combustion turbine coupled with natural gas firing in the heat recovery steam generator duct burners. During syngas-only operations, the plant will achieve a net generating capacity of 524 MW and a heat rate of 12,150 Btu/kWh. The facility will employ advanced emissions control equipment to produce marketable byproducts of ammonia, sulfuric acid, and carbon dioxide. Over 65 percent of the carbon dioxide will be captured, making the Kemper County Energy Facility's carbon emissions comparable to a natural gas-fired combined cycle power plant. The commercial operation date of the Kemper County IGCC plant will be May 2014.

The estimated 3 million metric tons of CO_2 per year captured from the Kemper County Energy Facility gasification process will be transported via pipeline to two off takers for use in enhanced oil recovery operations at depleted oil production fields in Mississippi.

Goals/Objectives

The primary objective of this project is to demonstrate the operation of a commercial-scale, air-blown transport gasifier technology and integrate it with a combined-cycle island. Other objectives of the project include (1) operating an advanced syngas cleanup system that includes sulfur removal and recovery; high temperature, high-pressure particulate filtration; and ammonia recovery and mercury removal; (2) demonstrating high availability, high thermal efficiency, low cost, and low emissions of the IGCC in commercial operating mode; and (3) operating an integrated CO_2 capture and compression system with the intent to capture and geologically sequester 65 percent of the CO_2 via enhanced oil recovery.

Benefits

The TRIG™ technology offers a simpler and more robust method for generating power from low-rank coal than other alternatives. It is unique among coal gasification technologies in that it is cost-effective when using both low rank coals and coals with high moisture or ash content. These coals make up half of the proved reserves in the U.S. and throughout the world. Moreover, the transport gasifier is capable of both air- and oxygen-blown operation. This inherent flexibility will allow future applications of this technology to be readily adapted to other applications beyond power generation, such as the production of chemicals used in industrial operations.

Moreover, the inclusion of CO_2 control as part of the project is critical to the future deployment of coal-based power generation in both the United States and the world. Installation of advanced power generation facilities is an important part of the strategy to become energy independent.

Aerial View of Kemper County Energy Facility (December 2012)

NT42391, March 2013

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PROJECT FACTS

Clean Coal Power Initiative (CCPI 3)

Hydrogen Energy California Project

Background

A need exists to further develop carbon management technologies that capture and store or beneficially reuse carbon dioxide (CO_2) that would otherwise be emitted into the atmosphere from coal-based electric power generating facilities. Carbon capture and storage (CCS) technologies offer great potential for reducing CO_2 emissions and mitigating global climate change, while minimizing the economic impacts of the solution.

Under the Clean Coal Power Initiative (CCPI) Round 3 program, the U.S. Department of Energy (DOE) is providing financial assistance, including funding under the American Recovery and Reinvestment Act (ARRA) of 2009, to industry to demonstrate the commercial viability of technologies that will capture CO_2 emissions and geologically store those emissions. Once demonstrated, the technologies can be readily considered in the commercial market-place by the electric power industry.

Artists Rendition of HECA Polygen - 400MWe (gross) Power Plant with 1 million ton/yr fertilizer production facility.

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PARTNERS

Mitsubishi Heavy Industries
Fluor Enterprises

PROJECT DURATION

Start Date	End Date
10/01/2009	04/01/2021

COST

Total Project Value
$4,028,136,691

DOE/Non-DOE Share
$408,000,000 / $3,620,136,691

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

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Project Description

DOE is providing financial assistance under CCPI Round 3 to Hydrogen Energy California LLC (HECA), along with private capital cost sharing, to demonstrate an advanced coal-fired generating plant that co-produces electricity and fertilizer products. The project will employ integrated gasification combined cycle (IGCC) technology to nominally generate 400 megawatts (MWe) gross and up to 300 MWe (net) of electricity and produce approximately one million tons per year of fertilizer using a 75 percent sub-bituminous coal and 25 percent petroleum coke fuel blend. The fertilizer could be a combination of urea ammonium nitrate (UAN), urea, or other fertilizer equivalent, with the proportion dependent on market and commercial conditions. The CO_2 off-take agreement contemplated by HECA will enable geologic storage of CO_2 at a rate of approximately 2.6 million tonnes per year. The captured CO_2 will be transported via pipeline to the Elk Hills oil field, approximately four miles from the power plant, for use in enhanced oil recovery (EOR). The design of these integrated facilities allows operating protocols that optimize: (1) the efficiencies of the physical plants while allowing steady state operation of the gasification unit; (2) the use of hydrogen to match product output volumes with demand under the terms of the urea/UAN and power off-take contracts; and (3) the use of the project's capital investment.

The project will utilize the Mitsubishi Heavy Industry (MHI) two-stage oxygen-blown gasification technology and combined cycle power block. A Rectisol® acid gas removal system will be employed to achieve the intended CO_2 capture efficiency. Water quality and availability issues are addressed by utilizing local brackish groundwater treated on-site to meet all industrial process water requirements. The brackish groundwater will be supplied from the Buena Vista Water Storage District (BVWSD), which is a local water district with some groundwater sources not suitable for agricultural use. The project will also incorporate a Zero Liquid Discharge (ZLD) system. All project wastewater, including wastewater generated from the IGCC, raw water treatment, and cooling tower blowdown will be directed to ZLD system(s) with the recovered water recycled for reuse in the process. This further reduces the water demands of the project.

Goals/Objectives

The goal of the project is to design, build, and operate a greenfield, commercial scale, fully integrated, advanced IGCC power plant and fertilizer production facility with CCS in Kern County, California. The project is designed to achieve at least 90 percent CO_2 capture efficiency while geologically storing approximately 2.6 million tonnes per year in an EOR application.

Benefits

The project will be among the cleanest of any commercial solid fuel power plant built or under construction and will significantly exceed the emission reduction targets for 2020 established under the Energy Policy Act of 2005. In addition, emissions from the plant will be well below the California regulation requiring baseload plants to emit less greenhouse gases than comparably-sized natural gas combined cycle power plants. The CO_2 captured by the project will enable geologic storage at a rate of approximately 2.6 million tonnes of CO_2 per year and will increase domestic oil production.

Specific project benefits include:

- Achieving approximately 90 percent CO_2 capture efficiency.
- Geologically storing approximately 2.6 million tonnes of CO_2 per year while producing about 5 million barrels of oil per year.
- Incorporating the beneficial use of CO_2 for EOR and geologic storage. EOR brings economic and energy security benefits.
- Meeting California's increasing power demands by generating low-carbon hydrogen power.
- Maximizing the use of local, non-potable brackish groundwater for all process and cooling needs will maintain area freshwater aquifers for agricultural use. All project wastewater will be directed to the 100 percent ZLD system, with the recovered water recycled for reuse in the process.
- Providing a low carbon footprint for California's key agricultural market and substantially lowering foreign imports of fertilizer to the U.S.
- Boosting California's economy by creating 2,500 local construction jobs and about 140 permanent operational positions.

FE0000663, May 2013

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PROJECT FACTS

Clean Coal Power Initiative (CCPI 3)

NRG Energy: W.A. Parish Post-Combustion CO_2 Capture and Sequestration Project

Background

Additional development and demonstration is needed to improve the cost and efficiency of carbon management technologies that capture and store carbon dioxide (CO_2) that would otherwise be emitted from coal-based electric power generating facilities. Carbon capture, utilization, and storage (CCUS) technologies offer great potential for reducing CO_2 emissions and mitigating global climate change, while minimizing the economic impacts of the solution.

Under the second closing of the Clean Coal Power Initiative (CCPI) Round 3 program, the U.S. Department of Energy (DOE) is providing financial assistance, including funding under the American Recovery and Reinvestment Act (ARRA) of 2009, to industry to demonstrate the commercial viability of next generation technologies that will capture and sequester CO_2 emissions. Once demonstrated, the technologies can be readily considered in the commercial marketplace by the electric power industry.

Project Description

The U.S. Department of Energy (DOE) is providing financial assistance under CCPI Round 3 to NRG Energy (NRG) to demonstrate the addition of a commercial-scale post-combustion carbon capture technology on its existing coal-fired W.A. Parish Generating Station (PGS) located in Thompsons, Texas, southwest of Houston, Texas. The project will demonstrate the ability of the Fluor Econamine FG PlusSM technology to capture 90% of the CO_2 emitted from a flue gas slipstream up to the equivalent of 240 Megawatts (MW) in size. The scale of the project is being increased because the original 60 MW program was determined to be too small to induce immediately significant oil production in most fields. This project scale-up is currently in development and will require additional capital on the part of the recipient.

The project will also demonstrate a number of innovative technological advances to the Fluor Econamine FG PlusSM solvent technology and captured CO_2 processing systems. The solvent was designed to remove CO_2 from coal-fired plant flue gas in which other components such as ash, sulfur dioxide, sulfur trioxide, nitrogen oxides, and oxygen are also present. Additionally, the solvent is readily available, inexpensive, and has relatively low energy requirements. The plant configuration will also allow the testing of advanced solvents being developed by Fluor and the University of Texas. Innovations in process equipment performance such as absorber intercooling and lean solvent vapor compression have the potential to reduce the energy requirements of these systems by as much as 20 percent. And finally, the host unit will not be derated because the power and thermal energy required to operate the CO_2 capture and compression system will be provided by a cogeneration plant comprised of a combustion turbine (CT) with a heat recovery boiler (HRB).

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University of Texas,
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PROJECT DURATION

Start Date
06/01/2010

End Date
11/30/2017

COST

Total Project Value (60 MW)
$338,607,740

DOE/Non-DOE Share (60MW)
$166,804,425/ $171,803,315
(240 MW project cost TBD)

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

These advances are anticipated to lower carbon capture costs and increase system flexibility and efficiency.

The captured CO_2 will be compressed and transported through an 80 mile pipeline to the West Ranch Oil Field in Jackson County, TX where it will be utilized for enhanced oil recovery (EOR) and ultimately sequestered.

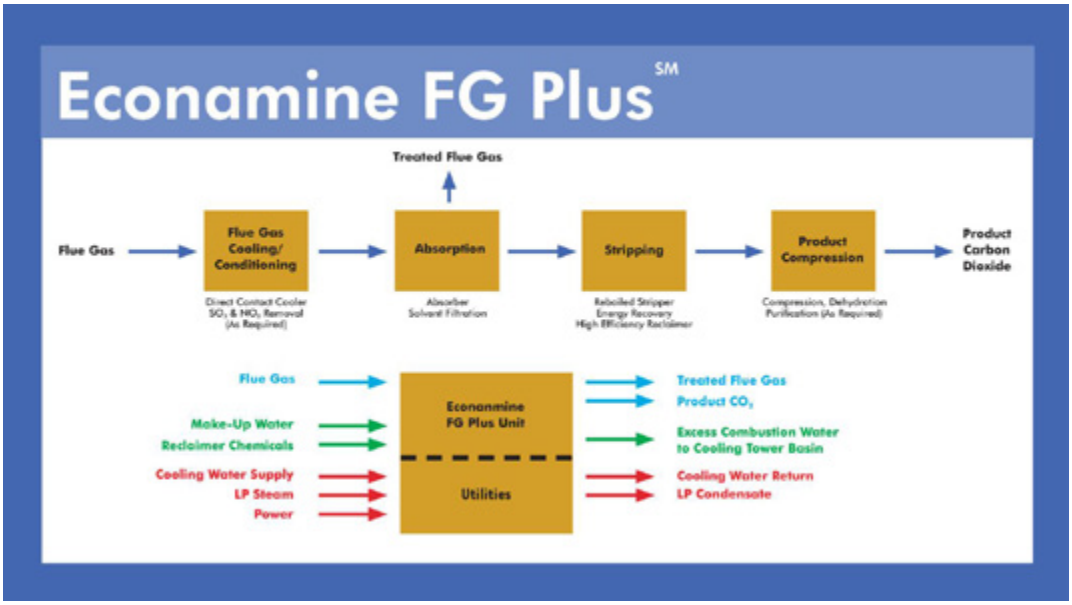
Goals/Objectives

The project goal is to advance fully integrated CCUS technologies from the demonstration stage to commercial viability. The project objective is to demonstrate CO_2 removal from treated flue gas from an existing coal-fired electrical generating station, and the compression and transport of the pipeline quality CO_2 to a sequestration site where it will be used for EOR.

Benefits

The W.A. Parish Post-Combustion CO_2 Capture and Sequestration Project represents an important step in advancing the commercialization of technologies that capture CO_2 from the flue gas of existing power plants. Standards that limit CO_2 emissions from coal-fired electrical generating stations do not yet exist, but it is possible that this type of regulation may be enacted in the future. The addition of CO_2 capture capability to the existing fleet of power plants will enable those plants to continue to produce clean electricity and simultaneously reduce the impact of CO_2 emissions. Specific project benefits are as follows:

- The capture of up to 1.4 million metric tons per year of CO_2 from a PGS flue gas stream.
- Increased domestic oil production in the U.S., which contributes to national energy security.
- Ultimate sequestration of the captured CO_2.
- A path forward for existing coal-fired power plants to continue energy production while meeting environmental sustainability goals.



FE0003311, March 2012

APPENDIX A: CCPI AND ICCS PROJECT FACT SHEETS

INDUSTRIAL CARBON CAPTURE AND SEQUESTRATION

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PROJECT FACTS

Industrial Carbon Capture and Sequestration (ICCS)

Leucadia Energy, LLC: Lake Charles Carbon Capture & Sequestration Project

Background

Carbon dioxide (CO_2) emissions from industrial processes, among other sources, are linked to global climate change. Advancing development of technologies that capture and store or beneficially reuse CO_2 that would otherwise reside in the atmosphere for extended periods is of great importance. Advanced carbon capture, utilization, and storage (CCUS) technologies offer significant potential for reducing CO_2 emissions and mitigating global climate change, while minimizing the economic impacts of the solution.

Under the Industrial Carbon Capture and Storage (ICCS) program, the U.S. Department of Energy (DOE) is collaborating with industry in cost sharing arrangements to demonstrate the next generation of technologies that will capture CO_2 emissions from industrial sources and either sequester those emissions or beneficially reuse them. The technologies included in the ICCS program have progressed beyond the research and development stage to a scale that can be readily replicated and deployed into commercial practice within the industry.

Project Description

The DOE selected Leucadia Energy, LLC to receive ICCS program funding through the American Recovery and Reinvestment Act (ARRA) of 2009, for its Lake Charles Carbon Capture & Sequestration (CCS) Project. The ICCS project will demonstrate the capture of CO_2 from an industrial facility for use in an independent enhanced oil recovery (EOR) application. The industrial source of CO_2 will be a petroleum-coke-to-chemicals (methanol and other by-products) gasification plant being developed by Lake Charles Cogeneration, LLC (a Leucadia Energy, LLC, affiliate) in Lake Charles, Louisiana. Once the CO_2 is captured, it will be purified to remove contaminants and compressed to a pressure suitable for commercial pipeline transport to oil fields in Texas and Louisiana for EOR. The project will also implement a comprehensive monitoring, verification, and accounting (MVA) program to confirm the long-term sequestration of a minimum of one million tons per year of the injected CO_2 at the Hastings oil field in Texas.

Goals/Objectives

The project goal is to advance CCUS technologies from the demonstration stage to commercial viability. The project objectives are to design, construct, and operate an integrated system of industrial-scale CO_2 capture, compression, and sequestration from a petroleum coke gasification plant for the beneficial reuse of CO_2 through EOR.

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Denbury Onshore, LLC
Black & Veatch Corporation
University of Texas Bureau of Economic Geology

PROJECT DURATION

Start Date	End Date
11/16/2009	09/30/2015

COST

Total Project Value
$435,587,194

DOE/Non-DOE Share
$261,382,310 / $174,204,884

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

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Benefits

The project will result in the large-scale recovery, purification, and compression of more than four million tons of CO_2 per year. The sale of CO_2 from the ICCS project for use in independent EOR operations by Denbury affords a cost effective means to increase domestic oil production while using advanced CCUS technology to beneficially use the recovered CO_2. On a global scale, petroleum coke currently being exported from the U.S. to regions where little, if any, environmental controls are required or implemented will now be used in a domestic chemical project that achieves superior environmental performance and captures CO_2 for beneficial use.

With the completion of the Green Pipeline by Denbury, naturally occurring CO_2 taken from the Jackson Dome in Mississippi will be used for EOR in oil fields in Texas and Louisiana. CO_2 from the project that is compressed and delivered to the Green Pipeline will represent approximately 25 percent of the daily amount of CO_2 that Denbury will use in these oil fields. By using the anthropogenic CO_2 from the Lake Charles plant, Denbury will be able to reduce the amount taken from the Jackson Dome and prolong the life of this naturally occurring source of CO_2. Additionally, a comprehensive MVA program will be implemented in the Hastings oil field that will confirm the long-term sequestration of injected CO_2 in the EOR project application.

The infrastructure developed by the ICCS project could potentially enable other industrial and power plant CO_2 sources in the Lake Charles industrial community to commercially dispose of CO_2 in Gulf Coast EOR operations. Expansion of EOR in the Gulf Region will promote greater energy security by increasing domestic energy supplies. The Lake Charles gasification facility and CCS project alone are expected to provide up to 1,100 construction jobs and 200 permanent operation jobs, as well as millions of dollars in severance taxes and royalties to the States of Louisiana and Texas.

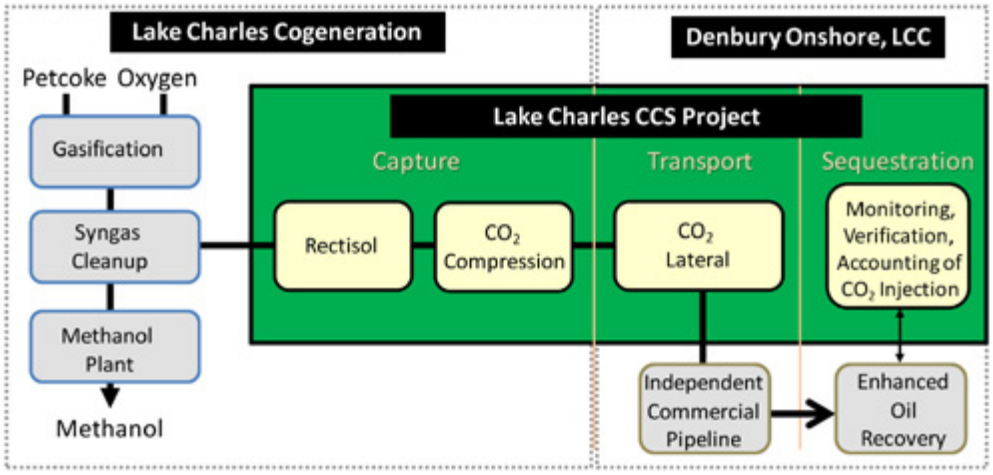

Diagram of the Lake Charles CCS Project

FE0002314, May 2012

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PROJECT FACTS

Industrial Carbon Capture and Storage (ICCS)

Archer Daniels Midland Company: CO_2 Capture from Biofuels Production and Storage into the Mt. Simon Sandstone

Background

Carbon dioxide (CO_2) emissions from industrial processes, among other sources, are linked to global climate change. Advancing development of technologies that capture and store or beneficially reuse CO_2 that would otherwise reside in the atmosphere for extended periods is of great importance. Advanced carbon capture, utilization and storage (CCUS) technologies offer significant potential for reducing CO_2 emissions and mitigating global climate change, while minimizing the economic impacts of the solution.

Under the Industrial Carbon Capture and Storage (ICCS) Program, the U.S. Department of Energy (DOE) is collaborating with industry in cost sharing arrangements to demonstrate the next generation of technologies that will capture CO_2 emissions from industrial sources and either sequester those emissions or beneficially re-use them. The technologies included in the ICCS program have progressed beyond the research and development stage to a scale that can be readily replicated and deployed into commercial practice within the industry.

Project Description

Partnership between DOE and Industry

In October 2009, DOE selected the Archer Daniels Midland Company (ADM) team to conduct one of 12 projects in Phase 1 of its ICCS program to test large-scale industrial CCUS technologies. DOE again selected the project in June 2010 as one of three projects to receive continued (Phase 2) funding. The Office of Fossil Energy's National Energy Technology Laboratory (NETL) manages the CO_2 Capture from Biofuels Production and Storage into the Mount (Mt.) Simon Sandstone project [Illinois Industrial Carbon Capture and Storage (Illinois ICCS) project], which receives $141.4 million in American Recovery and Reinvestment Act (ARRA) of 2009 funding and another $66.5 million in private sector cost-sharing. The project is scheduled for completion on September 30, 2015. The project team members are ADM, U.S. DOE, Schlumberger Carbon Services, Illinois State Geological Survey (ISGS), and Richland Community College (RCC). The Illinois ICCS project presents a unique opportunity to gather crucial scientific and engineering data in advance of carbon capture requirements to add to the understanding of large-scale CO_2 storage in saline formations. Successful implementation of this project could facilitate exploration of long-term CO_2 utilization options, such as enhanced oil recovery, in the Southern Illinois Basin.

Goals/Objectives

The overall project objective is to develop and demonstrate an integrated system of CO_2 processing and transport from an ethanol plant to the Mt. Simon Sandstone Formation (saline reservoir) for geologic sequestration.

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PARTNERS

Illinois State Geological Survey
Schlumberger Carbon Services
Richland Community College

PROJECT DURATION

Start Date	End Date
11/16/2009	09/30/2015

U.S. DEPARTMENT OF ENERGY

Project Scope

The Illinois ICCS project will demonstrate an integrated system for collecting CO_2 from an ethanol production plant and geologically sequestering it (deep underground storage) in a sandstone reservoir. The CO_2 produced is a byproduct from processing corn into fuel-grade ethanol at the ADM ethanol plant in Decatur, Illinois. Because all of the collected CO_2 is produced from biologic fermentation, a significant feature of the Illinois ICCS project is its "negative carbon footprint," meaning that the storage results in a net reduction of atmospheric CO_2.

The CO_2 will be sequestered in the Mt. Simon Sandstone, a prolific saline reservoir in the Illinois Basin with the capacity to store billions of tons of CO_2. Saline reservoirs are layers of porous rock that are saturated with brine (a concentrated salt solution). Mt. Simon Sandstone is a clean sedimentary rock dominated by silicate minerals and lacking significant amounts of clay minerals (which typically clog pores and reduce porosity), resulting in highly favorable porosity and permeability features for CO_2 storage. Supercritical CO_2 fluid will be injected into the saline reservoir at a depth of approximately 7,000 feet at a site adjacent to the ADM ethanol plant. Nearly 50 years of successful natural gas storage in the Mt. Simon Sandstone indicates that this saline reservoir and overlying seals should effectively contain sequestered CO_2.

The project scope includes the design, construction, demonstration, and integrated operation of CO_2 compression, dehydration, and injection facilities, and Monitoring, Verification, and Accounting (MVA) of the stored CO_2. More specifically:

- Design, construction, and operation of a new collection, compression, and dehydration facility capable of delivering up to 2,000 metric tons of CO_2 per day to the injection site.
- Integration of the new facility with an existing 1,000 metric tons per day CO_2 compression and dehydration facility to achieve a total injection capacity of up to 3,000 metric tons of CO_2 per day.
- Implementation and validation of deep subsurface and near-surface MVA plans.
- Demonstration of the cost advantages and economic viability of implementing CCS at ethanol production facilities.

Decatur, Illinois is home to two DOE-sponsored CCS projects:

Illinois Basin-Decatur Project (IBDP) led by ISGS under the Midwest Geological Sequestration Consortium (MGSC) Regional Carbon Sequestration Program: This is a large-volume, saline reservoir sequestration test that will inject approximately 333,000 metric tons of CO_2 per year for three years. MGSC, one of the seven DOE Regional Carbon Sequestration Partnerships, was established in 2003 to assess geologic carbon sequestration options in the Illinois Basin. ADM and ISGS have completed construction of the 1,000 metric tons per day CO_2 compression and dehydration facility and drilled and completed the associated injection and deep monitoring wells. The injection well is located adjacent to the ADM ethanol plant in Decatur. Carbon dioxide injection into the Mt. Simon Sand-stone began in November 2011 and will continue at a rate of 1,000 metric tons per day over a three-year period. For more details on IBDP and site geology, see: http://www.netl.doe.gov/publications/factsheets/project/Project678_4P.pdf

Illinois ICCS Project led by ADM: This project expands the CO_2 storage capability to that of a commercial-scale operation (i.e., one million tons per year). ADM will integrate the IBDP compression and dehydration facilities with the new facilities constructed under the Illinois ICCS project upon completion of IBDP injection operations in fall 2014. A significant benefit of these two complimentary projects is the unique opportunity to better understand the interaction between the CO_2 plumes and pressure fronts emanating from two injection wells in the same sandstone formation.

Carbon Dioxide Compression, Dehydration, and Transmission

The CO_2 will be collected at atmospheric pressure from ADM's corn-to-ethanol fermentors via a 36-inch pipeline. The fermentor outlet gas stream has high purity CO_2 (greater than 99% purity on a moisture free basis), but also contains some moisture (less than 3% by weight). This gas stream will be compressed and dehydrated to deliver supercritical CO_2 to the injection wellhead for storage. In this process the CO_2 will be compressed to 35 psia using a 3000 hp blower and sent via a 24-inch, 1,500-foot pipeline to a dehydration and compression facility. The CO_2 will be compressed and dehydrated at that facility to approximately 1425 psia and 95°F using a 3250 hp, 4-stage reciprocating compressor and a dehydration system that uses tri-ethylene glycol contactor (absorber)-regenerator columns. The CO_2 gas stream is also processed through various inter-stage coolers and knock-out vessels to decrease temperature and remove moisture, respectively. Finally, the dehydrated CO_2, which has less than 0.005% moisture by weight (>99.9% CO_2 purity), could be further compressed up to 2300 psia using a 400 hp centrifugal booster pump (if additional pressure is required) and transported about one-mile through an 8-inch pipeline to the injection wellhead. The injection operations will be conducted on a 200-acre site adjacent to the ethanol plant, which is also owned by ADM. The injection well head conditions will comply with the permit requirements.

CO_2 Injection

The Illinois ICCS project will initially inject CO_2 into the Mt. Simon Sandstone formation at a rate of 1,500 metric tons per day. The IBDP will also inject CO_2 at a rate of 1,000 metric tons per day during this period. The Illinois ICCS project's injection rate can be increased up to 3,000 metric tons per day once the IBDP project completes injection operations. Each project will have a separate injection well and the distance between the two wells will be approximately 3,700 feet.

At the injection location, the Mt. Simon Sandstone starts at a depth of approximately 5,500 feet below the surface and has a thickness of 1,500 to 1,600 feet. The CO_2 will be injected at a depth of about 7,000 feet where the IBDP project identified a high permeability zone with porosities up to 25%. Carbon dioxide injection will occur at depths far below the Underground Source of Drinking Water (USDW) level thus ensuring the safety of these water sources.

The Mt. Simon Sandstone is overlain by the 500-foot thick Eau Claire formation, of which the bottom 200 feet is primarily shale. The low-porosity Eau Claire Shale acts as the primary cap rock seal preventing upward migration of CO_2 from the Mt. Simon Sandstone. Two other shale formations, the Maquoketa and New Albany Shales, are present at shallower depths and act as secondary and tertiary seals, respectively. The base of the Mt Simon Sand-stone is underlain by Precambrian igneous bedrock (granite basement).

MVA of the Stored CO_2

The Illinois ICCS project will implement a robust MVA plan to monitor CO_2 migration and to protect groundwater sources. The MVA efforts will employ methods to provide an accurate accounting of the stored CO_2 and a high level of confidence that it will remain permanently stored deep underground. The MVA plan includes near surface and deep subsurface activities. Near surface monitoring includes aerial infrared imagery to monitor vegetative stress, an electrical resistivity survey of the soil to identify the geophysical nature of the near surface bedrocks, soil CO_2 flux to monitor changes in CO_2 concentrations, and shallow groundwater sampling for geochemical analysis. Deep subsurface monitoring includes geophysical (seismic) surveys and passive seismic surveys in the above cap rock seal locations and geophysical surveys, geochemical sampling, and pressure and temperature monitoring in the injection zone. A monitoring well (approximately 7200 ft. depth) and a geophysical well (approximately 3500 ft. depth) will be drilled for deep subsurface monitoring through direct and indirect measurements of the storage reservoir conditions. A baseline 3-D surface seismic study was conducted in February 2011. A geophysical analysis of the 3-D seismic data did not indicate any geologic faults in the cap rock seal at the proposed ICCS injection site. A lack of geologic faults offers greater certainty that the injected CO_2 will be strategraphically trapped in the Mt. Simon Sandstone. Other trapping mechanisms such as solubility trapping (dissolution of CO_2 in the brine solution) and residual trapping (CO_2 held in the pores) could also securely retain approximately 50% of the injected CO_2 in the sandstone.

Project Implementation Roles

- ADM: Overall project implementation, project host site, construction, operation, and ownership.
- Schlumberger Carbon Services: Site characterization, CO_2 injection well installation and operation, and deep subsurface MVA of the stored CO_2.
- ISGS: Site characterization, near-surface and deep subsurface MVA of the stored CO_2, education and outreach.
- RCC: National Sequestration Education Center development, CCUS training, community outreach, and development of an associate degree program in sequestration technology.

National Sequestration Education Center (NSEC)

Integral to the Illinois ICCS project will be the formation of an education and training facility, the National Sequestration Education Center (NSEC), housed at nearby RCC in Decatur. The center will contain classrooms, training and laboratory facilities, and it will offer an associate degree with a sequestration specialization. Richland shares the NSEC facilities with project partners and other stake-holders for conducting CCUS training and educational programs. The project partners will be providing the necessary expertise to develop these programs.

About Project Partners

ADM
ADM's global headquarters is located in Decatur, Illinois. Its more than 265 processing plants and 30,000 employees convert corn, oilseeds, wheat, and cocoa into products for food, animal feed, chemicals and energy uses. The net sales of ADM in fiscal year 2011 were $81 billion. www.adm.com.

Schlumberger Carbon Services
Schlumberger Carbon Services provides technologies and services for the long-term geologic storage of CO_2. Its experience and detailed understanding of the varied challenges posed by CO_2 storage, gained by participation in many carbon capture and storage projects worldwide, is backed up by a corporate history of over 80 years in the oil and gas industry. www.SLB.com/carbonservices

ISGS
The Illinois State Geological Survey (ISGS) leads the MGSC and is part of the Prairie Research Institute at the University of Illinois. The objective of the MGSC is to determine the technical and economic feasibility of using geologic formations for long-term CO_2 storage. www.sequestration.org.

COST

Total Project Value
$207,942,199

DOE/Non-DOE Share
$141,405,945 /$66,536,254

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

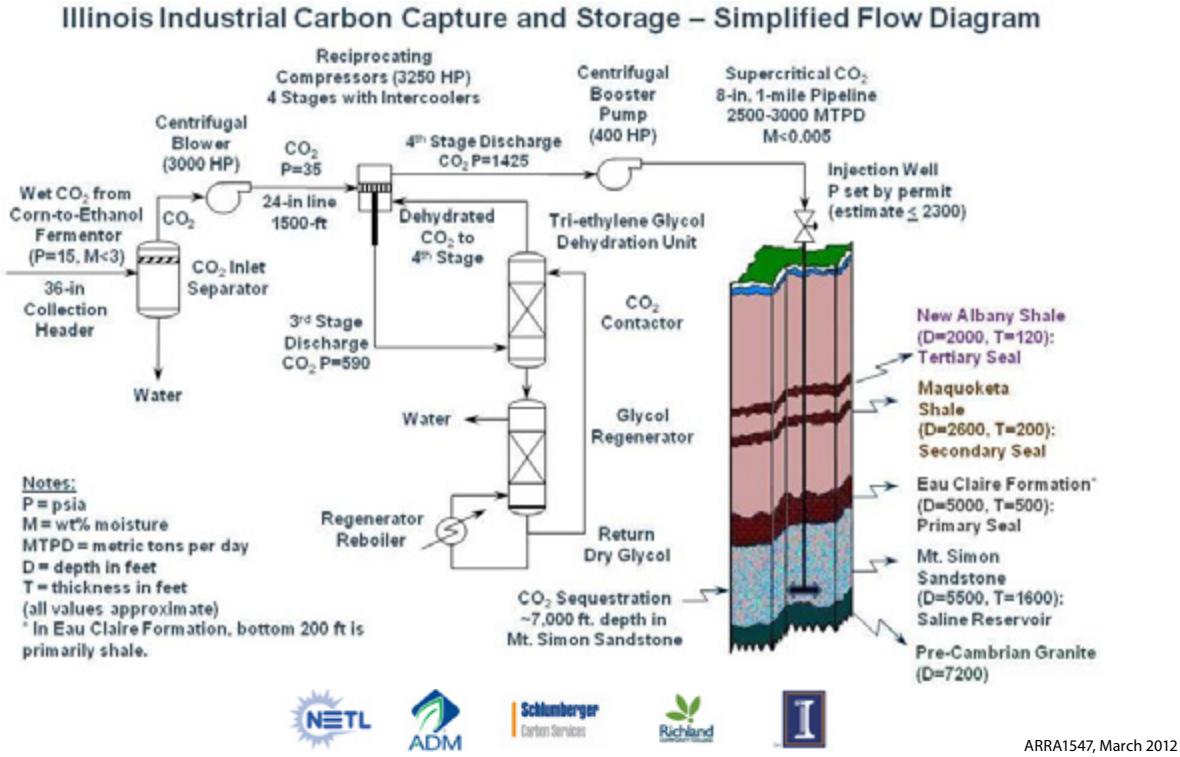
Richland Community College
Richland Community College, located in Decatur, Illinois, features a main campus and four major extension sites and offers over 150 degrees and certificates. The college has established itself as a vital asset to the community during its 40-year presence in Decatur-Macon County region. http://www.richland.edu/

Benefits

Carbon dioxide emissions from industrial processes and fossil-fuel power plants, among other sources, are linked to global climate change. Widespread deployment of large-scale CCUS technologies at stationary sources offer significant potential for reducing CO_2 emissions to the atmosphere and mitigating global climate change. The Illinois ICCS project is the largest saline storage demonstration project under construction in the U.S. The project addresses climate change concerns by collecting and compressing CO_2 derived from a large-scale industrial process and storing it in a saline reservoir. Specific advantages of the project include:

- Sequestration of approximately one million tons of CO_2 annually via a combination of existing and new processing capacity.
- A potential market for the technology in the U.S. for some of the approximately 200 fuel grade ethanol plants that have access to geologic storage.
- Utilization of U.S. geologic saline storage capacity of CO_2 that is estimated to range from 1,700 to 20,000 billion metric tons.
- Carbon dioxide concentration in the collected stream is already high, which enhances project economics.
- Project location is very near the CO_2 injection site, thereby avoiding the expense of developing a lengthy pipeline.
- Demonstration of capture and compression technology, as well as CO_2 storage experience, is applicable to coal-fired power generation.

ADM's Agricultural Processing and Biofuels Plant, Decatur, IL.



ARRA1547, March 2012

the ENERGY lab

PROJECT FACTS

Industrial Carbon Capture and Storage (ICCS)

Air Products and Chemicals, Inc.: Demonstration of CO_2 Capture and Sequestration of Steam Methane Reforming Process Gas Used for Large-Scale Hydrogen Production

Background

Carbon dioxide (CO_2) emissions from industrial processes, among other sources, are linked to global climate change. Advancing development of technologies that capture and store or beneficially reuse CO_2 that would otherwise reside in the atmosphere for extended periods is of great importance. Advanced carbon capture, utilization and storage (CCUS) technologies offer significant potential for reducing CO_2 emissions and mitigating global climate change, while minimizing the economic impacts of the solution.

Under the Industrial Carbon Capture and Storage (ICCS) program, the U.S. Department of Energy (DOE) is collaborating with industry in cost sharing arrangements to demonstrate the next generation of technologies that will capture CO_2 emissions from industrial sources and either sequester those emissions or beneficially reuse them. The technologies included in the ICCS program have progressed beyond the research and development stage to a scale that can be readily replicated and deployed into commercial practice within the industry.

Project Description

The DOE selected Air Products and Chemicals, Inc. (Air Products) to receive ICCS program funding through the American Recovery and Reinvestment Act (ARRA) of 2009, for its project entitled "Demonstration of CO_2 Capture and Sequestration of Steam Methane Reforming Process Gas Used for Large-Scale Hydrogen Production". For this project, Air Products will demonstrate a state-of-the-art system to concentrate CO_2 from two steam methane reformer (SMR) hydrogen production plants located in Port Arthur, Texas.

Air Products is retrofitting its two Port Arthur SMRs with a vacuum swing adsorption (VSA) system to separate the CO_2 from the process gas stream, followed by compression and drying processes. This process will concentrate the initial stream containing from 10-20 percent CO_2 to greater than 97 percent CO_2 purity.

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PARTNERS

Denbury Onshore, LLC

PROJECT DURATION

Start Date
11/16/2009

End Date
09/30/2015

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U.S. DEPARTMENT OF ENERGY

COST

Total Project Value
$430,648,802

DOE/Non-DOE Share
$284,012,496 / $146,636,306

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

Port Arthur 2 plant

The compressed CO_2 will then be delivered to the Denbury pipeline for transport to Texas EOR projects in the West Hastings Field where a monitoring, verification and accounting (MVA) program will ensure the injected CO_2 remains in the underground geologic formation. The technology will remove more than 90 percent of the CO_2 from the process gas stream used in a world-class scale hydrogen production facility with negligible impact on the efficiency of hydrogen production.

Project activities already completed include engineering and design. All air permits have been secured and construction is in progress. Commissioning, startup, and the operation of all components of the project are scheduled to occur by February, 2013. The MVA program to monitor the injected CO_2 is being designed and will be implemented once CO_2 capture begins.

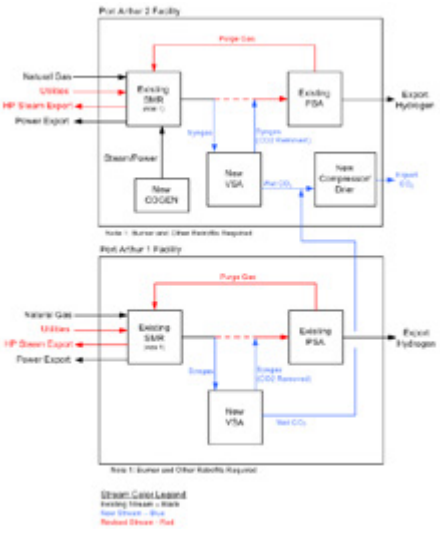
Goals/Objectives

The project goal is to advance CCUS technologies from the demonstration stage to commercial viability. The project objective is to capture CO_2 from two SMR hydrogen production plants and store it in an oil reservoir for EOR in order to successfully demonstrate the technology and maximize the economic viability of commercial-scale CCUS.

Benefits

Overall, the project will address climate change concerns, enhance U.S. economic and energy security, and boost domestic oil production. Specific project advantages and benefits include:

- Capturing approximately one million metric tons per year of CO_2, that would otherwise be emitted to the atmosphere, for permanent storage in geologic formations for EOR applications.
- The CO_2 to be used for EOR will result in approximately 1.6 to 3.1 million barrels of additional domestic oil production.
- The technology application is significant with the U.S. on-purpose hydrogen market for refinery use estimated to be almost four million tonnes annually. The two Port Arthur SMRs represent 4.3 percent of this market.



CO_2 System Sketch

FE0002381, October 2012